7. On the Vagus and Sympathetic Nerves of the Terrestrial Carnivora. By Charles F. Sonntag, M.D., F.Z.S., Anatomist to the Society.

[Received October 2, 1922: Read February 6, 1923.]

(Text-figures 1–14.)

The course, relations, and branches of the vagus and sympathetic nerves in the dog and cat are described in text-books, and Swan (1) has recorded some of the conditions present in the fox, jaguar, and porpoise. But no account of these nerves in the entire group of terrestrial Carnivora has been published. In the present paper, which is based on the examination of animals which died in the Society's Gardens, the conditions present in representatives of all families except the Hyænidæ, Protelidæ and Cryptoproctidæ, are described. The course and relations in all forms resemble those in the dog and cat.

The cervical parts of the vagus and sympathetic nerves may be fused or separate, or both forms may be present in the neck of the same animal.

The cervical parts are fused in :—

Family Felidæ :—*Felis domestica*, *F. onca*, *F. sylvestris*, *F. bengalensis*; Family Viverridæ :—*Nandinia binotata*, *Viverra civetta*, *Civettictis civetta*, *Viverricula malaccensis*, *Paradoxurus larvatus*, *Mungos mungo*, *M. ichneumon*, *Atilax paludinosus*, *Cynictis penicillata*; Family Canidæ :—*Canis familiaris*, *C. thous*, *C. bengalensis*, *Vulpes vulpes*, *Lycaon pictus*; Family Mustelidæ :—*Mustela martes*, *Meles meles*, *Putorius vison*, *Mephitis mephitica*, *Ictonyx zorilla*; Family Procyonidæ :—*Procyon lotor*, *Nasua narica*; Family Ursidæ :—*Melursus ursinus*. The degree of fusion varies. It may consist of an intimate mingling of the fibres, or the nerves may be easily separated when the fused sheaths are divided. The fusion may occur low down or high up. It is most extensive in *Nandinia binotata*, in which the ganglion nodosum of the vagus, and the superior cervical ganglion of the sympathetic are fused to form a lobulated mass (text-fig. 1 A). The vagus and inferior cervical ganglion are fused in *Canis thous* (text-fig. 5), *Paradoxurus larvatus* (text-fig. 6), and *Civettictis civetta* (text-fig. 7 B). The cervical parts are separate in *Genetta felina*, *Paradoxurus hermaphroditus*, and *Ailurus fulgens*. Both forms are present in the same animal in a specimen of *Lutra maculicollis*, the nerves being fused on the left side and separate on the right*.

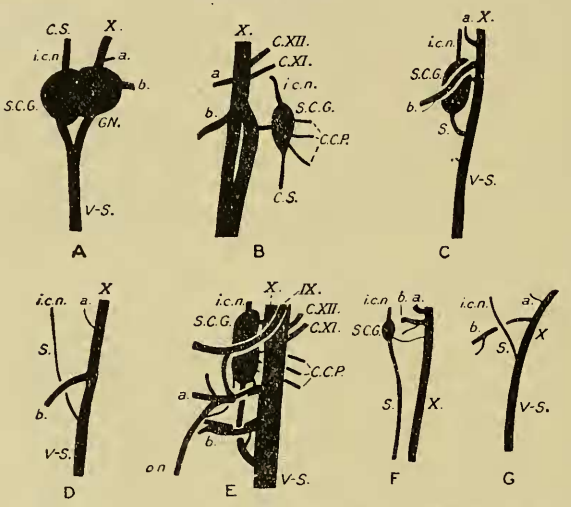
* A similar condition has already been recorded in *Tamandua tetradactyla* (4) and in *Anthropopithecus troglodytes*.

The Vagus Nerves.

The *ganglion nodosum* is absent in *Ailurus fulgens*, *Ictonyx zorilla*, *Paradoxurus larvatus*, *Melursus ursinus*, *Atilax paludinosus* and *Genetta felina* (text-fig. 1 B–G). It is represented by a thin, flat, expanded part of the nerve in *Civettictis civetta*, *Mustela martes*, *Meles meles*, and *Mephitis mephitica* (text-fig. 2); and in other genera it is a well-marked, round, oval, fusiform or pyriform swelling (text-fig. 3). Communications run as usual between it and the other nerves in its vicinity.

The *vago-sympathetic cord* (text-figs. 1, V-S.–11, V-S.) usually

Text-figure 1.



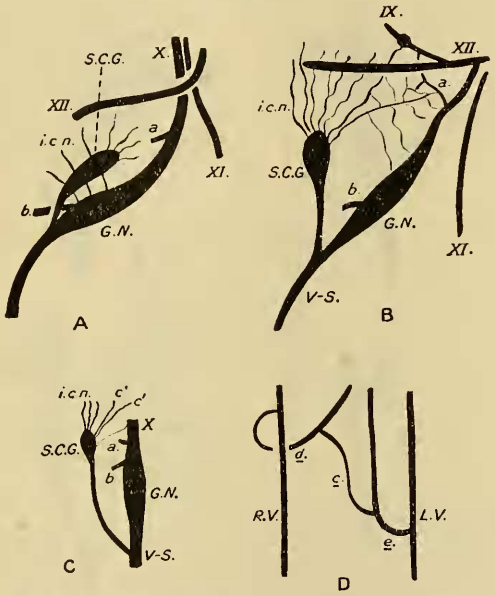
The upper cervical parts of the vagus and sympathetic nerves in: A. *Nandinia binotata*; B. *Ailurus fulgens*; C. *Paradoxurus larvatus*; D. *Atilax paludinosus*; E. *Melursus ursinus*; F. *Genetta felina*; G. *Ictonyx zorilla*; C.S: cervical sympathetic; X: vagus nerve; IX: glossopharyngeal nerve; XI: spinal accessory nerve; XII: hypoglossal nerve; G.N: ganglion nodosum; S.C.G: superior cervical ganglion; V-S: vago-sympathetic; C.C.P; communications to cervical plexus; *a*: pharyngeal nerve; *b*: internal laryngeal nerve; *i.c.n*: internal carotid nerve.

separates again into vagus (V.) and sympathetic (S.) in the posterior third of the neck, but they separate in the anterior part of the thorax in *Canis thous* (text-fig. 5). I believe the large swelling seen on the nerve in that species is a fusion of the vagus and inferior cervical sympathetic ganglion. It represents a greater degree of fusion than that seen in text-figs. 6 and 7 B.

Pharyngeal Nerve (text-figs. 1 *a*, 2 *a*, 3 *a*):—This nerve arises from the ganglion nodosum or from the nerve above it, the latter

being more frequent; and it runs to the pharyngeal plexus where it meets branches of the spinal accessory and sympathetic nerves. The accessory filaments usually pass through the vagus, but in *Canis familiaris* (1) they run separately. In *Mungos ichneumon* (text-fig. 3B) the pharyngeal nerve is given off from a laryngeal nerve. In *Procyon lotor* (text-fig. 3D) the pharyngeal nerve communicates with the superior laryngeal nerve; and in *Mustela martes* (text-fig. 2B) and *Civettictis civetta* (text-fig. 2A) the sympathetic communicates with it before it reaches the pharyngeal plexus.

Text-figure 2.



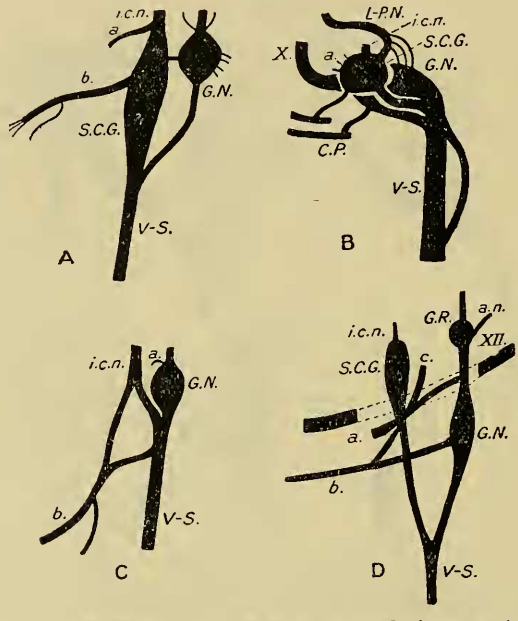
The upper cervical parts of the vagus and sympathetic nerves in: A. *Civettictis civetta*; B. *Mustela martes*; C. *Meles meles*; D. Anastomoses between the recurrent nerves in *Meles meles*; L.V. and R.V: left and right vagi; *d.* and *e*: right and left recurrent nerves; *c*: communicating nerves. Other letters as in text-fig. 1.

The *superior laryngeal nerve* (text-figs. 1*b*, 2*b*, 3*b*) is the largest branch given off from the ganglion nodosum, or from the upper part of the vagus when no ganglion is present. In *Mungos ichneumon* (text-fig. 3B) the superior cervical ganglion of the sympathetic gives off a large nerve (L-P-N.) which receives three filaments from the ganglion nodosum, and supplies the pharynx and larynx. The superior cervical ganglion, or sympathetic cord, communicates in some cases with the superior laryngeal nerve by small branches, or by a thick cord, as in *Canis thous*

(text-fig. 3C). The nerve gives off the external laryngeal nerve and enters the larynx through the thyro-hyoid membrane, or through an opening in the thyroid cartilage. It is sometimes seen to communicate with the recurrent nerve, but never in such a complete manner as that described in *Hyrax capensis* (5). No trace of a *depressor nerve* was seen in any of the animals described in the present paper, although it is described by several authors as existing in *Felis domestica*.

As the middle cervical sympathetic ganglion is absent, no

Text-figure 3.



The upper cervical parts of the vagus and sympathetic nerves in: A. *Felis bengalensis*; B. *Mungos ichneumon*: C. *Canis thous*; D. *Procyon lotor*; G.R: root ganglion of the vagus; *a.n*: Arnold's nerve. Other letters as in text-fig. 1.

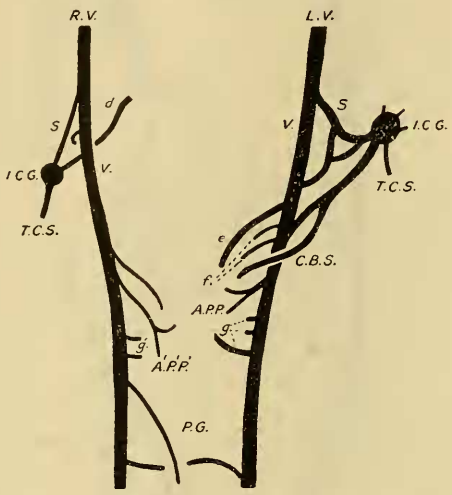
communicating twigs are given off from the vagus till the root of the neck is reached. There the sympathetic is given off and communicating branches run again between vagus and sympathetic. They run to the sympathetic cord itself, or to the inferior cervical ganglion of the sympathetic (text-figs. 4–11). In *Procyon lotor* they run from the vagus to the annulus of Vieussens.

The cervical part of the œsophagus is supplied by the pharyngeal and, in some cases, the recurrent laryngeal nerves.

The *right recurrent laryngeal nerve* (text-figs. 4,*d*–11,*d*) has the usual origin, course, and relations. It may communicate with the sympathetic and cardiac plexuses. In *Meles meles* (text-fig. 2 D) a thick nerve unites it to the left recurrent nerve, and in *Mephitis mephitica* (text-fig. 11 A) it forms a loop with the right vagus, whence cardiac branches arise.

The left vagus usually runs straight across the aortic arch, but in *Canis thous* (text-fig. 5) it is very tortuous, and its branches are also undulating, so the aortic arch is covered by sinuous nerves.

Text-figure 4.



The lower cervical and thoracic parts of the vagus nerves in *Felis bengalensis*. L.V. and R.V: left and right vago-sympathetic nerves; V: vagi; S: sympathetics, A.P.P. and A'.P'.P': anterior pulmonary plexuses; C.B.S: cardiac branches of the sympathetic; I.C.G: inferior cervical ganglion of the sympathetic; P.G: plexus gulæ; T.C.S: thoracic sympathetic cords; *d* and *e*: right and left recurrent laryngeal nerves; *f*: cardiac branches of the vagus; *g* and *g'*: pulmonary branches of the vagus.

The *left recurrent laryngeal nerve* (text-figs. 4,*e*–11,*e*) arises from any point in the vagus above, in front of, or below the aortic arch. It has the usual course, relations, and terminations. It gives twigs to the cardiac plexus, and it may communicate with the left anterior pulmonary plexus.

Tracheal and œsophageal branches arise in the thorax, and the former make a more or less complex plexus.

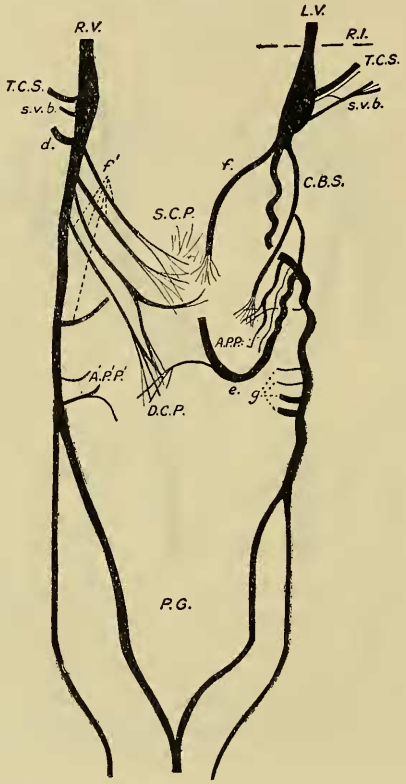
Cardiac Nerves (text-figs. 4, *f.f'*–11, *f.f'*):—In none of the terrestrial Carnivora did I observe any cervical cardiac branches

of either vagus; and all the branches arose within the thorax from:—

a. The vagus nerves (constant).
b. The left recurrent nerve (constant).
c. The right recurrent nerve (not universal).

In all forms the vagus cardiac branches contain some sympathetic filaments, but in a few species they contain the entire

Text-figure 5.



The thoracic parts of the vagus nerves in *Canis thous*. D.C.P. and S.C.P: deep and superficial cardiac plexuses; R.I: first rib; *s.v.b*: sympathetic nerves on subclavian arteries. Other letters as in text-fig. 4.

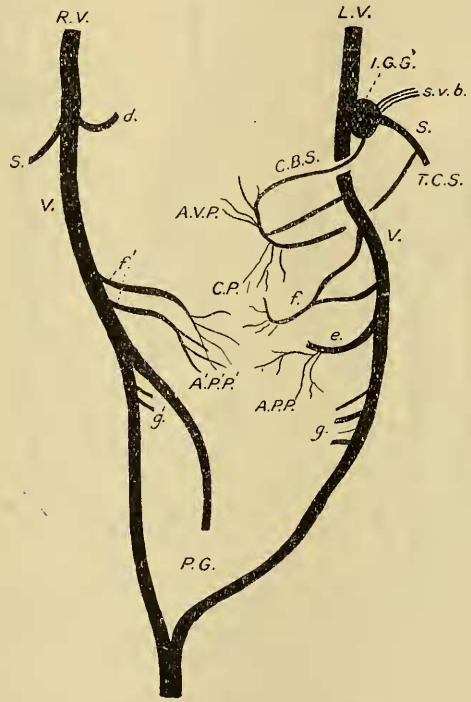
sympathetic supply to the heart. The cardiac plexuses anastomose with the anterior pulmonary plexuses, and with the nerves round the branches of the aortic arch. In some cases (text-figs. 4, 5, 6) the vagus gives off well-marked nerves, whose bifurcating terminal twigs run to both cardiac and anterior pulmonary nerves. The actual components of the plexuses are described on p. 76.

Anterior Pulmonary Nerves (text-figs. 4, A.P.P.–11, A′.P′.P′.) arise from the vagi anterior to the pulmonary roots, or as bifurcations from cardio-pulmonary branches.

Posterior Pulmonary Nerves (text-figs. 4, *g.g.*–11, *g.g′.*), which are two to four in number, arise from the vagi as they run along the dorsal surfaces of the roots of the lungs. They may be very short and minute, or long and thick.

Plexus Gulæ (text-figs. 4–11):—Between the roots of the lungs and the diaphragm there is a more or less intricate anastomosis between the vagi across the œsophagus. There may be only

Text-figure 6.



The lower cervical and thoracic parts of the vagus nerves in *Paradoxurus larvatus*. *s.v.b*: sympathetic nerves on the subclavian arteries. Other letters as in text-fig. 4.

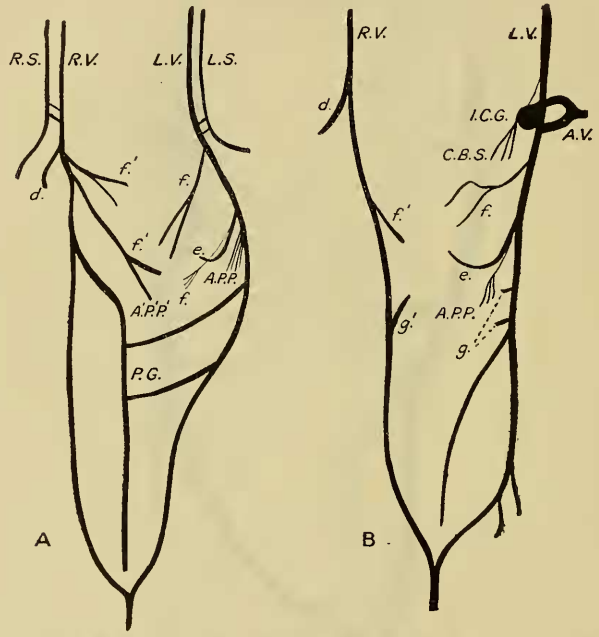
branches of communication, but in most forms there is a mingling of divisions of the vagi. From the plexus two cords emerge; one runs through the ventral aspect of the œsophageal orifice in the diaphragm and the other through its dorsal aspect. The arrangements observed by me were:—

In *Nandinia binotata*, *Mephitis mephitica* (text-fig. 11 A),

Cynictis penicillata (text-fig. 10 B), and *Melursus ursinus* (text-fig. 11 B) the ventral cord is formed by the left vagus, the dorsal cord by the right one, and communications run between the nerves.

In *Felis bengalensis* (text-fig. 4) and *Paradoxurus larvatus* (text-fig. 6) the ventral cord is a branch of the right vagus and the dorsal cord is a combined trunk of the vagi. In the former communications run between the vagi. In *Genetta felina* (text-fig. 7) the ventral cord and left vagus are united by communications.

Text-figure 7.



The thoracic parts of the vagus nerves in: A. *Genetta felina*; B. *Civettictis civetta*. Letters as in text-fig. 4.

In *Civettictis civetta* (text-fig. 7 B), *Ailurus fulgens* (text-fig. 10 A), *Lutra maculicollis* (text-fig. 8 A), and *Putorius vison* (text-fig. 8 B) the dorsal cord is a combined trunk of the vagi, and the ventral cord is a branch of the left vagus.

In *Procyon lotor* (text-fig. 9 B) the ventral and dorsal cords are produced by both vagi after forming a complex plexus gulæ.

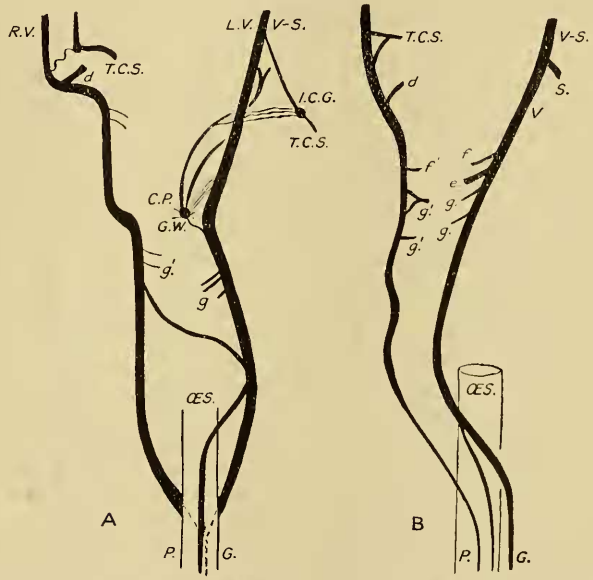
In *Canis thous* (text-fig. 5) both vagi divide. The mesial halves unite to form the ventral cord, and the lateral halves fuse to form a very thick dorsal cord.

The ventral and dorsal cords end in different ways in the

abdomen. In *Felis bengalensis* (text-fig. 12) the ventral cord sends branches over the ventral gastric wall and lesser curvature. They anastomose with branches of the right vagus and off-shoots of the solar plexus accompanying the gastric and duodenal arteries. The right vagus supplies dorsal gastric nerves and divides into two bundles of fibres which end in the cœliac ganglia (C.G.), gastric (G.P.), splenic (S.P.), superior mesenteric (S.M.P.), and left renal (L.R.P.) plexuses.

In *Civettictis civetta*, *Atilax paludinosus*, *Genetta felina*, *Ictonyx zorilla*, *Mephitis mephitica*, *Melursus ursinus*, and *Ailurus fulgens* the ventral cord divides into branches which supply the ventral

Text-figure 8.



The thoracic parts of the vagus nerves in: A. *Lutra maculicollis*; B. *Putorius vison*; G.W: ganglion of Wrisberg; ŒS: œsophagus. Other letters as in text-fig. 4.

surface of the stomach and course along the lesser curvature to the pylorus. The dorsal cord sends a few branches to the lesser curvature and dorsal wall of the stomach and ends in the solar plexus; it always remains large and thick.

In *Paradoxurus larvatus* (text-fig. 13) the conditions are very complex. The ventral cord (V.C.) supplies the stomach, as in the preceding forms, by thin gastric branches (*g.b.*), but it also gives off the hepatic plexus (H.P.). The dorsal cord (D.C.) gives off a large gastric nerve (G.P.), several twigs to the hepatic plexus (H.P.), the splenic plexus (S.P.), and many communicating

branches to the solar plexus (c.S.P.). It is continued into the superior mesenteric plexus (S.M.P.), one branch in particular being thick and reaching the cæcum (Ca). These sympathetic plexuses even if traversing the vagus cord have come from the solar plexus.

In *Canis thous* the ventral cord runs along the lesser curvature of the stomach to the pylorus, but it does not give off the hepatic plexus. The dorsal cord supplies the dorsum of the stomach, communicates with the solar plexus by a large cord, and sends many branches into the solar offshoots. Many branches can be traced through the superior mesenteric plexus to the cæcum.

In *Cynictis penicillata* the right vagus replaces the ventral cord in the species described above, but has a similar course. The left one runs through the dorsal aspect of the œsophageal opening in the diaphragm, supplies the stomach, and breaks up into filaments which pass to the offshoots of the solar plexus.

It is now believed that the Arctoid Carnivora have genetic relations to the Cetacea, and Swan (1) described the conditions in *Phocæna communis* as follows:—"In the porpoise the par vagum communicates with the sympathetic, but is otherwise separate from this, as in the baboon, rabbit, and others; it gives off a small recurrent which winds round the subclavian artery on the right side, and the arch of the aorta on the left; it sends filaments to the œsophagus; it gives several branches to the heart, and copiously supplies the lungs; it then passes to the œsophagus, where its branches are more deeply imbedded in the muscular fibres than in other animals; the greater portion corresponding with the posterior trunk supplies the first, or cuticular, and the second, or villous, stomach; after forming a corona or ring on the lower part of the œsophagus, it sends filaments to the diaphragm and to the left semilunar ganglion; it also sends branches towards the other three stomachs or duodenal pouches, a branch to the liver, and others to communicate with branches from the cœliac plexus on the branches of the coronary artery passing to the stomachs, and with some of the branches of the hepatic plexus as this passes to the liver; the smaller portion corresponding with the anterior trunk passes down and sends some filaments to the lower portion of the œsophagus and the first stomach, but its principal part divides to join both semilunar ganglia."

It is, therefore, evident that there is a greater degree of communication between the vagi and solar plexus in the porpoise than in the Arctoid Carnivora, both trunks being connected to the semilunar ganglia. Complications are introduced owing to the differences in the characters of the stomach.

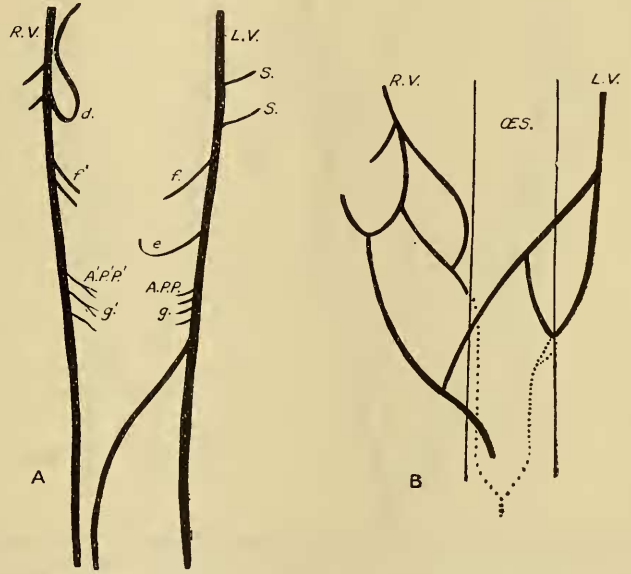
The Sympathetic Nervous System.

The *superior cervical ganglion* (text-figs. 1, S.C.G.–3, S.C.G.) is absent in *Atilax paludinosus*, *Ictonyx zorilla*, and *Canis thous*,

and I could neither observe it in the neck nor in the carotid canal. In other species it is round, oval, or pyriform, but its posterior pole is never bifurcated. It communicates with the ninth, tenth, and twelfth cranial nerves, and it sends branches to the pharyngeal plexus. The internal carotid nerve (*i.c.n.*) is single or multiple. Rami communicantes also run to the upper cervical spinal nerves.

The superior cervical ganglion and ganglion nodosum are fused in *Nandinia binotata* (text-fig. 1 A), but in other animals the former rests on the vagus nerve, or is connected to it by a sympathetic cord (S.) of variable length. In only a few species (p. 65) is the sympathetic always separate from the vagus.

Text-figure 9.



A. Thoracic parts of the vagus nerves in *Ictonyx zorilla*; B. Plexus gulæ in *Procyon lotor*. Letters as in text-fig. 4.

In no case is there a *middle cervical ganglion*.

When a vago-sympathetic cord is present it is usually resolved again into its component elements in the posterior third of the neck. But in *Canis thous* (text-fig. 5) the vago-sympathetic passes into the thorax, and expands into an oval mass whence the sympathetic runs cranio-laterad. The sympathetic enters the inferior cervical ganglion or the first dorsal ganglion when the former is absent.

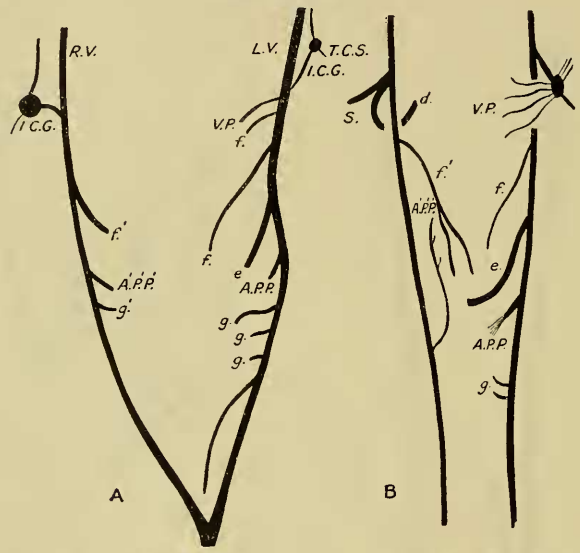
The *inferior cervical ganglion* (text-figs. 4, I.C.G.–11, I.C.G.) is absent in *Putorius vison*, *Atilax paludinosus*, *Genetta felina*, and

it is, in my opinion, represented by the swelling on the vagus in *Canis thous* (text-fig. 5). In *Civettictis civetta* (text-fig. 7 B) it is fused with the medial border of the left vagus, but it is absent on the right side. It may communicate with the right recurrent nerve. Branches run to the brachial plexus, and vaso-motor filaments accompany the vessels to the fore-limbs.

In *Canis thous* (text-fig. 5, *s.v.b.*) the latter arise independently from the vagus enlargement. Branches accompany the vertebral artery through the cervical vertebræ.

Cardiac branches reach the cardiac plexuses in three ways. In most species they are contained within branches of the vagus.

Text-figure 10.



Thoracic parts of the vagus nerves in: A. *Ailurus fulgens*; B. *Cynictis penicillata*; V.P: nerve plexus round branches of the aortic arch. Other letters as in text-fig. 4.

In some forms they reach the cardiac plexuses through the plexus round the aortic arch and its branches. In others they run directly to the cardiac plexuses.

The inferior cervical ganglion is united to the first thoracic ganglion by one or more nerves, or by an annulus of Vieussens.

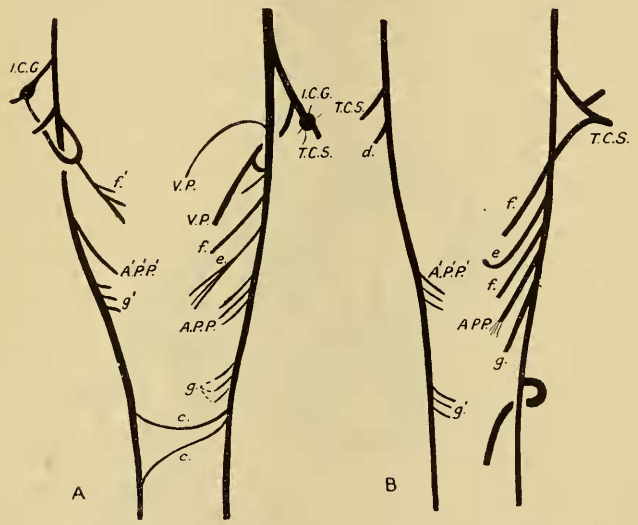
Pulmonary branches may be included within the vagus, or fine filaments may run to the lungs from the upper thoracic ganglia. It may, however, be difficult to trace the latter.

Cardiac Plexus:—The cardiac plexus lies between the aortic arch and trachea, and in some species there is an aggregation of nerves with or without ganglia, lying in the position of the

superficial cardiac plexus. It is connected to the anterior pulmonary plexus on one or both sides, and to a plexus around the main branches of the aortic arch. In some species branches of the vagus and sympathetic reach the cardiac plexus through the latter. The composition of the plexus in the species described in this paper are :—

Felis bengalensis (text-fig. 4):—Two branches from the left vagus (*f*), a twig from the left anterior pulmonary plexus (A.P.P.), and a thick branch from the inferior cervical ganglion of the left sympathetic (C.B.S.). These form a superficial plexus without ganglia. The deep plexus receives a branch from the right vagus (*f'*), a branch from the right anterior pulmonary

Text-figure 11.



Thoracic parts of the vagus nerves in: A. *Mephitis mephitica*; B. *Melursus ursinus*; V.P: nerve plexus round branches of the aortic arch. Other letters as in text-fig. 4.

plexus (A'.P'.P'.), and a branch from the left recurrent laryngeal nerve; but it gets no separate sympathetic filaments.

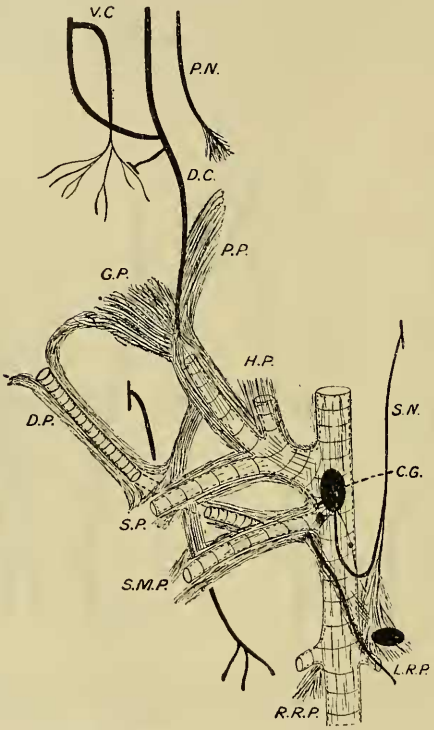
Paradoxurus larvatus (text-fig. 6):—Two offshoots of the left vagus unite to form a cardiac nerve (*f*) which runs to the plexus. No branches of the left sympathetic run directly to the plexus, but they enter the plexus round the branches of the aortic arch (A.V.P.). The right vagus gives two branches (*f'*) and the left recurrent laryngeal nerve contributes; but no branches come from the right sympathetic. The plexus communicates with the pulmonary plexus.

Atilax paludinosus (text-fig. 8 C):—Each vagus contributes

two branches (*f.f'*) and the left recurrent laryngeal nerve (*e*) sends a twig. No sympathetic filaments run directly to the plexus on either side.

Genetta felina (text-fig. 7 A):—The left vagus and its recurrent laryngeal branch send each a branch to the plexus, and the former bifurcates (*f*). The right vagus sends two large cords (*f'*),

Text-figure 12.



Abdominal parts of the vagus and sympathetic nerves in *Felis bengalensis* C.G: cœliac ganglia; D.C: dorsal cord of the vagi; D.P: duodenal plexus; G.P: gastric plexus; H.P: hepatic plexus; L.R.P. and R.R.P: left and right renal plexuses; P.N: left phrenic nerve; P.P: phrenic plexus; S.M.P: superior mesenteric plexus; S.N: splanchnic nerve; S.P: splenic plexus; V.C: ventral cord of the vagi.

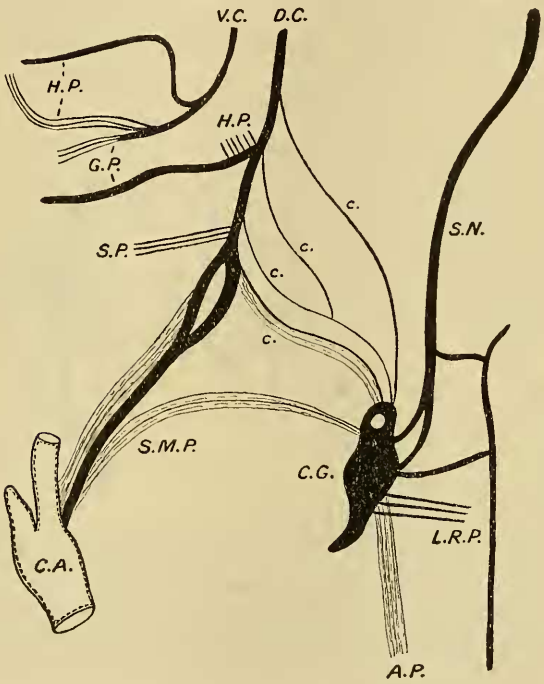
which both divide before reaching the plexus. No separate sympathetic filaments run to it on either side.

In *Civettictis civetta* (text-fig. 7 B) the plexus is formed by a branch from each vagus (*f.f'*) and a brushwork of fibres from the left nerve. Filaments from the left inferior cervical sympathetic

ganglion reach it via the plexus round branches of the aortic arch.

In *Canis thous* (text-fig. 5) the superficial and deep plexuses are very well marked. The former (S.C.P.) receives a thick cord from the left vagus (*f*), several twigs from the right vagus (*f'*), communications from the left anterior pulmonary plexus, and a thick sympathetic filament (C.B.S.). The latter (D.C.P.) is formed by branches of the right vagus (*f'*), left recurrent

Text-figure 13.



Abdominal parts of the vagus nerves in *Paradoxurus larvatus*. A.P: aortic plexus; C.A: cæcum; *c*: communicating nerves. Other letters as in text-fig. 12.

laryngeal nerve (*e*), and communications with the right anterior pulmonary plexus; but there are no separate sympathetic filaments.

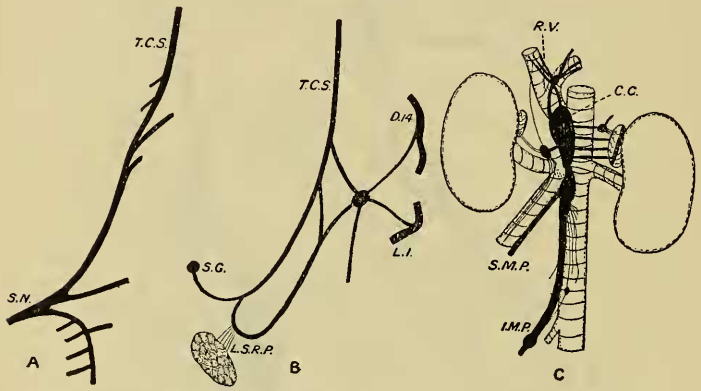
In *Cynictis penicillata* (text-fig. 10 B) the cardiac plexus receives a branch from each vagus (*f*,*f'*), one from the left recurrent nerve (*e*), and communications from the anterior pulmonary plexuses (A.P.P.). No branches come separately from the right sympathetic, but the left inferior cervical ganglion (I.C.G.) sends

numerous fine filaments to the aortic plexus, the latter being connected to the cardiac plexus.

In *Mephitis mephitica* (text-fig. 11 A) a marked plexus grouped round the great vessels (A.V.P.) receives branches from the left vagus and left inferior cervical ganglion. The cardiac plexus receives a twig from each vagus (*f.f'*), one from the left recurrent laryngeal nerve (*e*), and a brushwork of filaments from a right vago-sympathetic loop.

In *Melursus ursinus* (text-fig. 11 B) superficial and deep cardiac plexuses are present and communicate with pulmonary plexuses. The superficial plexus gets a branch from the left vagus (*f*), but both vagi and the left recurrent laryngeal nerve supply the deep one. Neither plexus gets separate sympathetic filaments.

Text-figure 14.



A. *Paradoxurus larvatus*, showing the thoracic sympathetic cord (T.C.S.) becoming the splanchnic nerve (S.N.); B. *Canis thous*, showing the thoracic cord (T.C.S.) becoming the great splanchnic nerve, the small splanchnic filaments ending in the left suprarenal plexus (L.S.R.P.) and a sympathetic ganglion giving rami communicantes to spinal nerves (D. 14 and L. 1); C. Solar plexus in *Meles meles*: I.M.P: inferior mesenteric plexus. Other letters as in text-fig. 12.

The *Thoracic Gangliated Cord* does not always possess the same number of ganglia as intercostal nerves. When ganglia are absent the rami communicantes meet the sympathetic cords in T- or V-shaped junctions. Ganglia may be minute or well-marked but are larger in marine than in terrestrial Carnivora. The splanchnic branches vary as follows:—

a. One thick cord arises on each side in the thorax and breaks up into several filaments before entering the solar plexus:—*Felis bengalensis* (text-fig. 12), *Civettictis civetta*.

b. One large thoracic cord and some fine abdominal nerves constitute the splanchnic nerves:—*Felis domestica*, *Cynictis*

penicillata, *Ictonyx zorilla*, *Mephitis mephitica*, *Ailurus fulgens*, and *Melursus ursinus*.

c. The thoracic cord becomes the main splanchnic nerve, and the others come from the abdominal sympathetic. The remainder of the sympathetic cord appears as a branch of the main splanchnic in *Paradoxurus larvatus* (text-fig. 14 A). In *Canis thous* (text-fig. 14 B) the main splanchnic cord gives a branch to a ganglion whence the abdominal sympathetic passes caudad, and two long rami communicantes run to the last dorsal and first lumbar nerves.

Branches of the thoracic cord to the aortic plexus vary in prominence.

The *Solar Plexus* varies considerably in details, but it is built on the same general plan in all. It lies on one side of, or is wrapped round the cœliac axis. It has always at least one large ganglion, but smaller ones may be present in addition. It receives the dorsal vagus cord and splanchnic nerves, and its offshoots accompany the various abdominal arteries, interlacing at their terminations. Sometimes the hepatic and splenic plexuses are apparently given off from the right vagus. Superior and inferior mesenteric ganglia may be present, and these are most marked in *Meles meles* (text-fig. 14 C). As filaments of the right vagus get into many, if not all, of the offshoots the abdominal organs get a rich supply of both vagus and sympathetic filaments. The following list contains an enumeration of the offshoots :—

1. Phrenic plexus.
2. Gastric ,,
3. Hepatic ,,
4. Splenic ,,
5. Duodenal ,,
6. Superior mesenteric plexus.
7. Renal plexuses.
8. Suprarenal plexuses.
9. Spermatic ,,
10. Ovarian ,,
11. Inferior mesenteric plexus.
12. Aortic plexus.

All the offshoots are not equally obvious in all the Carnivora. The most variable is the duodenal plexus, which depends on the presence or absence of a large duodenal branch of the superior mesenteric artery (text-fig. 12).

The Sympathetic Nervous System in Phocæna communis.

Swan (1), in his description gives the following data :—

1. The pyriform superior cervical ganglion of the sympathetic nerve sends one portion upwards and one downwards.

2. The sympathetic communicates with the superior laryngeal nerve.

3. The inferior cervical ganglion on the right side communicates with the vagus, but the left one does not.

4. The thoracic ganglia are well marked, and on the whole larger than in other mammalia; they give off aortic and

splanchnic nerves, rami communicantes and lateral branches to the *rete mirabile* on the thoracic parietes*.

5. The aortic plexus has a large ganglion.

6. The rectum and bladder receive small nerves.

7. There is no perceptible difference in the nerves to the upper and lower part of the intestines, just as these parts of the gut merge gradually into one another, and there is no capacious cæcum.

It is, therefore, evident that the sympathetic nerves differ in many respects from those in the Fissipede Carnivora.

Swan has also made several generalizations on the sympathetic nerves in the Mammalia, and the conditions described in this paper furnish illustrations of his remarks which, as far as the Carnivora are concerned, were made on a very limited series of animals.

Summary and Conclusions.

1. In most Carnivora Fissipedia the cervical parts of the vagus and sympathetic nerves are fused. In most cases fusion only affects the cords, but in a few species the ganglia are also united. Fusion consists either of an intimate mingling of fibres or adhesion of sheaths only.

2. The ganglion nodosum is frequently absent in both the neck and the foramen lacerum posticum; and the superior cervical ganglion of the sympathetic is likewise absent in a few species.

3. No middle cervical ganglion is present, and inferior cervical ganglia are frequently absent.

4. Sympathetic cardiac nerves are frequently contained entirely in branches of the vagi.

5. The cardiac plexus is sometimes divisible into superficial and deep parts, but ganglia are uncommon.

6. Pulmonary nerves may arise from cardiac branches of the vagi.

7. The plexus gulæ varies in complexity. It may be absent. In most species ventral and dorsal cords produced by a varying degree of intermingling of the vagi pass from thorax to abdomen.

8. The ventral vagus cord supplies the ventral gastric wall and branches run along the lesser curvature to the pylorus.

9. The dorsal vagus cord supplies the dorsum of the stomach. It ends directly in the cœliac ganglia or in one of the offshoots of the solar plexus, or it is diffused throughout the plexus.

10. The number of ganglia on the thoracic sympathetic cord does not always correspond to that of the intercostal nerves.

* The *rete* disseminated throughout the body enables the animal to accommodate itself to variations in the water pressure when it dives or rises to the surface; and the sympathetic nerves running to the thoracic *rete* form part of the accommodating neuro-vascular mechanism.

11. The superior and inferior cervical ganglia are variable, but the middle cervical sympathetic ganglia are absent.

12. Thoracic sympathetic ganglia are absent, small or large.

13. The splanchnic nerves may be branches or continuations of the thoracic cords, and a branch of the great splanchnic becomes the abdominal sympathetic in the latter case.

14. Well-marked nerves are traceable from the vagus and solar plexus to the cæcum.

15. The vagus nerve may give off plexuses which arise from the solar plexus in most mammals.

16. The vagus and sympathetic nerves of the terrestrial Carnivora differ in many details from those of *Phocæna communis*, the latter being more complex in several respects.

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